RESEARCH ARTICLE

Impact of Formulated Protein Diets on Growth of the Indian Major Carp, Labeo rohita (Hamilton)

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Impact of Formulated Protein Diets on Growth of the Indian Major Carp, *Labeo rohita* (Hamilton)

S Manivannan*, TS Saravanan
Postgraduate Department of Zoology, Jamal Mohamed College, Tiruchirappalli, Tamil Nadu, India.

***Correspondence to:** Subramanian Manivannan, mani3677@gmail.com

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Abstract
Fresh water aquaculture in India is mainly carp-based and accounts for a considerable proportion of total aquaculture production. Feeding constitutes a major factor in fish culture since the fish obtain the maximum nutritional requirement through the food they consume. Protein forms one of the main components of fish feed and hence formulation of feeds that contain high amount of protein using cost-effective natural ingredients is very essential to achieve efficient production from fish culture. *Labeo rohita* is an extensively studied fish and contributes to a considerable proportion of fish production in India. In the present investigation, four different kinds of fish feed (using groundnut cake, azolla, rice bran and tapioca powder) were formulated with varying protein concentrations (30%, 35%, 40% and 45%) and given to *L. rohita* to assess the impact of the protein diet on its growth and bioenergetic parameters. The fish were fed with the formulated feed at a rate of 4% of their body weight for a period of 60 days. It was observed that the fish fed with formulated feed containing 40% protein content showed better growth results and improvement in bioenergetic parameters, compared to the other three feeds.

Keywords: Aquaculture; formulated feed; growth rate; *Labeo rohita*; Indian major carp.

1. Introduction

Aquaculture has a great role to play in the welfare of mankind. It is emerging as one of the most viable and promising enterprises for providing notional and food security for humans. Food production from agricultural resources cannot keep pace with the ever increasing human population around the globe. *Labeo rohita*, commonly called as Rohu and one of the three Indian major carps, is an important freshwater fish species normally cultured in Asia, particularly in the Indian subcontinent [1]. Rohu culture contributes to about 35% of the total Indian major carp production [2].

The intensification of fish culture has led to dependence on artificial feeds. Protein is the most expensive component in fish feeds and also the most important factor affecting growth performance of fish and feed cost [3]. Reducing the feeding costs could be a key factor for the successful development of aquaculture. Fish have high dietary protein requirement [4]. The significance of qualitative and quantitative feeds is well recognized [5] and the level of dietary protein is of fundamental importance, because it significantly influences growth, survival and yield of fish. Therefore, considerable research effort is needed to determine the quantity and quality of dietary protein necessary to achieve optimum growth performance of fish.

To formulate a low cost feed, ingredients from plant and animal sources are used to fulfill the protein requirement of the fish meal, fully or partially. The inter-relationship between the dietary energy requirement and the growth of fish and the importance of proper protein nutrition has been well established. So, fish nutritionists pay greater attention to reduce the cost of artificial diets by introducing alternative protein sources from plant and animal [6].

Growth responses and survival of fish when they are fed with artificial diets depend upon several factors, the feeding levels being one of the most important. The effect of varying feeding rates on the growth feed consumption, efficiency and body composition of a number of species has been well studied [7]. In a similar context, the present study was aimed to assess the impact of formulated protein diet on the growth of the Indian major carp, *Labeo rohita* (Hamilton).

2. Methods

2.1. Experimental animals

The major carp *L. rohita* were obtained from a commercial fish farm in Thanjavur, Tamil Nadu, India, and maintained in the laboratory under optimum conditions. The water quality was monitored at 15 days interval during the entire experimental period (60 days) following standard methods [8]. The average water temperature, dissolved oxygen, free carbon dioxide, pH, and total alkalinity based on daily measurements were maintained at 27.5–28.9°C, 67–7.1, 5.5–10.7, 7.5–7.8, and 65.7– 80.5 mg l^{-1}, respectively.

Before initiation of the feeding trial, the fish were acclimated to experimental conditions for 2 weeks. The fish were fed with a diet containing groundnut cake and rice bran in a ratio of 1:1 during this period.

2.2. Experimental diet and feeding

Groundnut cake, azolla, rice bran and tapioca powder were used to prepare the experimental diets. These components were selected based on plant protein: groundnut cake and azolla consist of high protein; rice bran and tapioca consist less protein. In addition to these, vitamin–mineral mixture was also added. The composition of all these ingredients is shown in Table 1.

Table 1: Composition of experimental diets.

Ingredients	Diet (g/100g)			
	I	II	III	IV
Groundnut cake	17.3	27.8	38.3	48.8
Azolla	17.3	27.8	38.0	48.8
Rice bran	32.7	22.2	11.7	1.2
Tapioca powder	32.7	22.2	11.7	1.2
Vitamin + mineral mix	1.0	1.0	1.0	1.0

Before formulating the diet, the ingredients were processed as follows: All the ingredients were separated in a mesh of 2 mm size to get uniform sized powder and were weighed appropriately according to the protein requirement of the dietary formulation in the experiment (Table 2).

Table 2: Biochemical composition of four different experimental diets.

Diet	Ingredients	Protein (%)	Carbohydrate (%)	Fat (%)
I	Groundnut cake	9.5	5.76	0.61
	Azolla	6.3	0.64	0.21
	Rice bran	8.2	12.10	5.85
	Tapioca powder	6.0	19.69	0.33
	Total	**30**	38.19	7.00
II	Groundnut cake	15.2	9.26	0.97
	Azolla	10.1	1.03	0.33
	Rice bran	5.6	8.21	3.97
	Tapioca powder	4.1	13.36	0.22
	Total	**35**	31.86	5.49
III	Groundnut cake	21.0	12.89	1.34
	Azolla	14.0	1.4	0.46
	Rice bran	2.9	4.33	2,09
	Tapioca powder	2.1	7.04	0.12
	Total	**40**	16.68	4.01
IV	Groundnut cake	26.7	16.25	1.71
	Azolla	17.8	1.81	0.59
	Rice bran	0.3	0.44	0.21
	Tapioca powder	0.2	0.73	0.01
	Total	**45**	29.23	2.52

These ingredients were thoroughly mixed using optimum quantity of water to make dough. This mixed dough was cooked for about 30 minutes, and then the vitamin–mixture was added. The hot dough was passed through domestic extruded noodles over air dried to reduce moisture content and then broken into small pellets (0.5–10 cm length). These pellets were used for the preparation of fish feed.

Thirty-two young-ones of Rohu weighing 8.5 to 20.7 g were chosen and divided into 4 groups (8 in each group), designated as L-I, L-II, L-III and L-IV. The fish were reared in round troughs (45 cm × 27.5 cm) with 35 L of water in each trough. Before commencement of the experiment, the fish were allowed to evacuate their alimentary contents, and the initial weight and total length were noted for each fish. Then, the fish were fed with the formulated diets in two split doses per day, i.e., at 10.00 and 17:30 hours every day, till day 60, after which they were collected separately and subjected to growth performance and bioenergetics studies.

2.3. Growth parameters and digestibility

At the end of the feeding trial, growth performance of the fingerlings was evaluated in terms of the following parameters, estimated using Halver's procedures [9]:

$$\text{Weight gain \%} = \frac{\text{Final body weight} - \text{Initial body weight}}{\text{Initial body weight}} \times 100$$

$$\text{Specific growth rate (SGR)} = \frac{\text{Final body weight} - \text{Initial body weight}}{\text{No. of days}} \times 100$$

$$\text{Food conversion ratio (FCR)} = \frac{\text{Diet consumption}}{\text{Weight gain}}$$

$$\text{Feeding rate} = \frac{\text{Diet consumption}}{\text{Weight gain}} \times \text{No. of days}$$

$$\text{Assimilation} = \frac{\text{Food consumption}}{\text{Fecal output}}$$

$$\text{Protein efficiency ratio (PER)} = \frac{\text{Weight gain}}{\text{Assimilation}}$$

$$\text{Apparent protein digestibility (APD)} = \frac{\text{Assimilation}}{\text{Food consumption}} \times 100$$

2.4. Statistical analysis

Statistical analysis of the data was performed using SPSS software program (SPSS 14. Chicago, IL, USA). One-way Analysis of Variance with Tukey's test was used to compare the different groups. Results are expressed as mean ± standard deviation. P values less than 0.05 were considered as statistically significant.

3. Results

Four types of pelleted diets were prepared containing different proportions of protein: Diet I was prepared to have 30% protein, Diet II 35% protein, Diet III 40% protein and Diet IV 45% protein (Table 2). Each group of fish was fed with each type of diet: Group L-I fed with Diet I, Group L-II fed with Diet II, Group L-III were fed with Diet III and Group IV fish with Diet IV. The rate of feeding was 4% of entire wet body weight.

3.1. Growth parameters and digestibility

The results of the impact of experimental feed on the growth and bioenergetic parameters of the fish *L. rohita* are given in Table 3.

Table 3: Growth and bioenergetics parameters (Mean ± SD)*.

*Superscript letters in the table denote statistically significant values. Values with same superscript letters in the same row are not significantly different; while values with different superscript letters compared between the groups in the same row represent statistically different values. Exact p values are mentioned in the text.

Parameters	L-I	L-II	L-III	L-IV
Weight gain	60.48±5.28^{a}	70.98±5.38^{b}	88.75±4.98^{c}	66.84±4.32^{abd}
SGR	9.97±1.21^{a}	14.35±1.65^{b}	21.20±1.48^{c}	20.92±1.26^{cd}
FCR	3.09±0.18^{a}	2.72±0.17^{b}	2.56±0.14^{bc}	3.05±0.17^{ad}
Feeding rate	1.85±0.06^{a}	1.63±0.04^{b}	1.53±0.02^{c}	1.83±0.04^{ad}
Assimilation	8.97±0.79^{a}	8.03±0.74^{ab}	12.08±0.58^{c}	12.22±0.66^{cd}
PER	5.34±0.70^{a}	8.57±0.60^{b}	9.53±0.47^{bc}	9.17±0.55^{bcd}
APD	6.06±0.48^{a}	4.27±0.46^{b}	3.63±0.39^{bc}	3.97±0.44^{bcd}

3.1.1. Percentage weight gain

The group L-III fish fed with 40% protein diet showed a significant increase in weight gain (88.75±4.98%) compared to the other groups (P<0.05). The respective percentage weight gain values for groups L-I, L-II and L-IV are 60.48±5.28%, 70.98 ± 5.38% and 66.84±4.32%.

3.1.2. Specific growth rate

The highest SGR of 21.2±1.48% was observed in group L-III, which was statistically significant compared to the SGR values of groups L-I (9.97±1.21; p<0.01) and L-II (14.35±1.65) (p<0.05). L-IV showed an SGR value of 20.92±1.26%, which was also significantly high compared to that of groups L-I (p=0.01) and L-II (p=0.03).

3.1.3. Food conversion ratio

Food conversion was highly efficient in the group L-III, which showed an FCR of 2.56±0.14, which was statistically significant compared to the values in groups L-I (3.09±0.18) (p=0.03) and L-IV (3.05±.01) (p<0.05). The group L-II showed an FCR of 2.72±.017.

3.1.4. Feeding rate

Feeding rate was also highly efficient in the group L-III, with a value of 1.53±0.02, which was statistically significant compared to the values in the groups L-I (1.85±0.06), L-II (1.63±0.04) and L-IV (1.83±0.04) (p<0.05).

3.1.5. Assimilation

Assimilation of the protein diets was found to be highest in groups L-III (12.08±0.58) and L-IV (12.22±0.66). These values were statistically significant compared to those in groups L-I (8.97±0.79) and L-II (8.03±0.74) (p<0.01). No significant difference was observed between L-III and L-IV.

3.1.6. Protein efficiency ratio

The PER value was highest in the group L-III (9.53±0.47), which was statistically significant compared to L-I (5.34±0.7) (p<0.01). The values in groups L-II (8.57±0.6) and L-IV (9.17±0.55) were also significantly higher compared to L-I (p<0.01).

3.1.7. Apparent protein digestibility

Remarkable variations in protein digestibility among the 4 groups were observed. Group L-I showed the highest digestibility value of 6.06± 0.48 and L-III showed the least value of 3.63 ± 0.39 (P<0.05). The digestibility values of L-II and L-IV were observed to be 4.27±0.46 and 3.97± 0.44, respectively.

4. Discussion

Fish nutritionists have tried since years to replace the expensive fish meal component of fish feeds with less expensive plant protein feed stuffs. For maximum growth of fish, optimum protein content in the feed is necessary. However, efficient utilization of protein depends on the availability of other dietary nutrients like carbohydrate and fats in appropriate quantities. Fish convert practical feeds into body tissue more efficiently than do farm animals. Generally, protein is recognized as a frequent limiting factor for growth of herbivorous fish. Studies pertaining to nutrition in freshwater aquaculture had resulted in the development of new feed formulations for Indian carps [10].

The present investigation on *L. rohita* fed with four different pelleted diets, using the same ingredients but in varied proportions, showed significant variations in growth and bioenergetics parameters among the different groups of fish. The fish fed with 40% protein diet (Group L-III) exhibited significant increase in length, weight gain and food conversion ratio.

Group L-III had the least feeding rate of 153 mg/day but showed a high assimilation of nutrients. Sampath and Vivekanandan [11] also observed a decrease in the feeding rate, with increasing assimilation efficiency in the fish *Channa striatus*. Kumar [12] reported that 40% protein diet was optimum for *Cyprinus carpio* for food achievement in terms of growth, bioenergetic and biochemical parameters.

The fish also showed a maximum increase in weight in group L-III, which decreased as the protein content was increased to 45% in Group L-IV. Such a trend was also reported earlier [12] in *C. carpio*, in which 91.9% weight gain was observed in the fish fed with 40% protein diet. The best food conversion ratio was also observed in the current study with the fish fed with 40% protein diet. Similar findings were reported by Singh and Bhanot [13] in the Indian major carp *Catla catla*. In addition, it was observed in the present study that 40% protein diet in *L. rohita* revealed the highest net growth efficiency, indicated by the highest specific growth rate in Group L-III.

Increase in dietary protein has often been associated with higher growth rate in many fish species. However, there is a certain level beyond which further growth is not supported, and may even decrease [14, 15]. Such a scenario was observed in the present study, as well. Most of the growth and bioenergetics parameters of *L. rohita* increased with increasing protein content from 30% to 40% and then decreased with 45% protein diet (Group L-IV).

Thus, it is apparent from the overall findings of the present investigation that *L. rohita* fed with supplementary feed containing 40% protein level showed better growth performance results. High percentages of weight gain, specific growth rate, and assimilation were observed in this group of fish. Further, the cost for the preparation of these diets was found to be cheaper when compared with other commercial and traditional diets.

Feeds from plant origin have been reported to be effective and less expensive ingredients for formulation of fish diets. These feeds are known to have an excellent amino acid profile [16]. In the past few decades, feeds from plant origin have been accepted for Indian major carps because the growth observed in these fish has been reported to be as good as that obtained with the traditional feed. In tropical developing countries, where algal production rates are high, algae have been receiving increasing attention as an alternate protein possessing relatively high protein content (50–65%), which may be included in balanced fish feeds [17].

The present study revealed that 40% protein diet would be optimum for the maximum growth of *L. rohita*. The study also revealed that not only the quantity but also the quality of the fish protein increased. Further, the cost of the preparation of the above diet was cheaper than other commercial and traditional diets.

5. Conclusion

The results of the present study could help fish feed industrialists to prepare cheap and specific feed from the locally available raw materials for the better growth and survival rate of *Labeo rohita* (Hamilton) and also help the fish farmers to get maximum yield in a minimum period of time for the carps fed with cheap and proper feed.

Competing Interests

The authors declare no conflict of interest.

Authors' Contributions

MS helped in designing the study, performed the experiments and drafted the manuscript. STS designed the study and helped in drafting the manuscript.

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